

INTEGRAL observations of the X-ray burster 4U 1850–087: first detection of hard X-ray emission extending above 50 keV

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Abstract. The X-ray burster 4U1850–087, located in the globular cluster NGC 6712, is an ultracompact binary likely harbouring a degenerate companion. The source has been observed with INTEGRAL several times, during the monitoring of the Galactic plane, with an unprecedented exposure time. The broad-band spectrum (2–100 keV; INTEGRAL together with a quasi-simultaneous XMM-Newton observation) is well described with a disk-blackbody emission ($kT_{in}=0.8$ keV) together with a power-law (photon index of 2). We report here the first detection of hard X-ray emission from this source above 50 keV. A lower limit on the presence of a high energy cut-off can be placed at $E_c > 100$ keV.

Keywords: X-rays; Neutron Stars; X-ray Binaries

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INTRODUCTION

4U 1850–087 is an X-ray burster located in the galactic globular cluster NGC 6712, associated with an optical counterpart which displays an UV modulation [1] with a period of 20.6 minutes. If interpreted as the orbital period, this implies a degenerate companion of $0.04M_{\odot}$ [2]. The first broad-band spectrum was obtained with BeppoSAX in the energy range 0.3–50 keV in 1997 [3], with an estimated 0.1–100 keV luminosity of 1.9×10^{36} erg s^{−1} (assuming a distance of 6.8 kpc). Other X-ray observations below 10 keV have been performed with ASCA [4], XMM-Newton[5], *Chandra* [6]. We discuss here the first detection of 4U 1850–087 above 50 keV with the INTEGRAL satellite (the details are reported in [7]).

OBSERVATIONS AND RESULTS

The ESA *INTEGRAL* gamma-ray observatory was launched in October 2002 and carries three co-aligned coded mask telescopes: the imager IBIS [8], which allows high angular resolution imaging over a large field of view ($29^{\circ} \times 29^{\circ}$) in the energy range 15 keV–10 MeV, the spectrometer SPI ([9]; 20 keV–8 MeV) and the X-ray monitor JEM-X ([10]; 3–35 keV).

We analyzed 909 individual pointings (Science Windows, SWs) within 10° from the source position, performed between March 2003 and November 2005 during the Galactic plane monitoring. The version 5.1 of the OSA INTEGRAL analysis software

has been used to process the data. 4U 1850–087 is a faint source, therefore a meaningful spectral analysis has been performed adding together several observations. Thus we grouped the pointings in four data-sets (listed in Table 1), from which we extracted four different IBIS/ISGRI spectra, adopting the standard spectral extraction method.

TABLE 1. Summary of all INTEGRAL observations analysed here. Four data-sets have been considered for brevity. We list the Start and Stop Time of the four groups of observations (3rd and 4th columns), together with the number of SWs in each data-set (5th column).

Data set	Temporal window	Start Time (MJD)	End Time (MJD)	Num of SWs
1	Mar 2003–May 2003	52708.7	52772.0	258
2	Sep 2003–Nov 2003	52910.9	52963.4	210
3	Mar 2004–May 2004	53075.1	53126.5	84
4	Aug 2004–Nov 2005	53238.1	53684.0	357

We fit independently the four IBIS/ISGRI spectra with a single power-law, resulting in a photon index in the range 2–2.7 (90% confidence level), with no evidence for a long-term spectral changing; the source flux (20–100 keV) varied within a factor ~ 2 (from 0.8×10^{-10} erg cm $^{-2}$ s $^{-1}$ to 1.8×10^{-10} erg cm $^{-2}$ s $^{-1}$).

We extracted also JEM-X spectra, but the smaller field of view, the faintness of the source, together with some instrumental issues, severely reduced the number of useful observations. Thus data could be used only for the data-set 3 and part of the data-set 4, with a net exposure of 76.7 ks and 55.5 ks respectively in the two JEM-X units (5–20 keV). When combined together, the JEM-X plus IBIS/ISGRI simultaneous spectrum (data-set 3) is well fitted with an absorbed power-law (column density fixed at 2.5×10^{21} cm $^{-2}$, the expected interstellar absorption towards the globular cluster NGC 6712) with a photon index of 2.2 ± 0.2 . The 5–100 keV flux corrected for the absorption is $(2.4 \pm 0.3) \times 10^{-10}$ erg cm $^{-2}$ s $^{-1}$ (based on the IBIS/ISGRI response matrix, $\chi^2/\text{dof}=27.9/23$).

4U 1850–087 has been observed with XMM–Newton on 27 September 2003 [5], i.e. within the period covered by INTEGRAL data-set 2, with the main aim to study the low energy absorption intrinsic to the source. We combined EPIC PN and IBIS spectra in order to interestingly extend the spectral study of this source in the soft X-rays below 5 keV. The best-fit resulted in a disk-blackbody emission together with a power-law (see Fig. 1 for the energy spectrum), with the following parameters: an absorbing column density of $(4 \pm 2) \times 10^{21}$ cm $^{-2}$, a photon index of $2.07^{+0.07}_{-0.15}$, a disk-blackbody temperature, kT_{in} , of 0.8 ± 0.1 keV, and a inner disk radius of $r_{\text{in}} \times (\cos(i))^{0.5} = 1.7^{+1.1}_{-0.4}$ km (at 6.8 kpc). The source flux (2–100 keV) corrected for the absorption is 2.8×10^{-10} erg cm $^{-2}$ s $^{-1}$ (based on the EPIC pn response matrix). Adopting a cut-off power-law instead of a power-law in the two-component model ($\chi^2/\text{dof}=172.2/202$), the cut-off energy resulted in $E_c > 110$ keV (90% confidence level), with a best-fit photon index of 1.9 ± 0.1 .

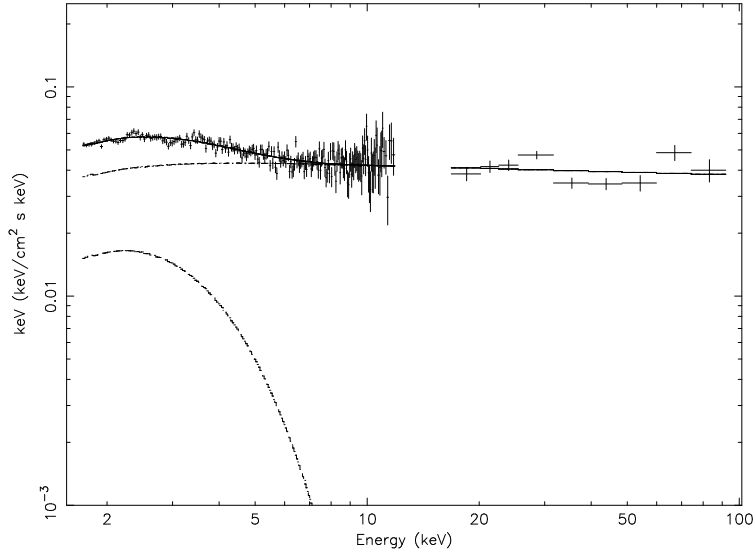


FIGURE 1. Broad-band 4U 1850–087 EPIC/PN spectrum (obtained in September 2003) combined with the quasi-simultaneous IBIS/ISGRI (data-set 2), fitted with a disk-blackbody plus a power-law.

DISCUSSION AND CONCLUSIONS

4U 1850–087 was previously observed at high energies only with BeppoSAX in April 1997, up to 50 keV [3]. Here we report the discovery of hard (50–100 keV) X-ray emission from 4U 1850–087 and a long-term study of its X-ray spectral behaviour. In order to properly compare INTEGRAL and BeppoSAX high energy spectra, we re-analysed the BeppoSAX observation adopting the same model used here, a disk-blackbody emission together with a power-law. This resulted in an absorbing column density of $(0.46 \pm 0.03) \times 10^{22} \text{ cm}^{-2}$, an inner disk blackbody temperature, kT_{in} , of $0.66 \pm 0.03 \text{ keV}$, and a powerlaw photon index of 1.96 ± 0.06 , in very good agreement with the INTEGRAL spectroscopy.

The new observations with INTEGRAL interestingly allow us to put much more stringent limits on the presence of a high energy cut-off. The confidence contour levels for the high energy cut-off and the power-law photon index are compared in Fig. 2. During the BeppoSAX observation a lower limit to the high energy cut-off could be placed at $E_c > 60 \text{ keV}$ (90% level), while now with INTEGRAL we can interestingly shift it towards much higher energies, with $E_c > 100 \text{ keV}$. This allows us to conclude that 4U 1850–087 belongs to the class of the hardest type I X-ray bursters in our Galaxy, and the analysis of the four different INTEGRAL spectra suggests that the source spends most of its lifetime in this hard spectral state (on timescales of months or years, if compared with BeppoSAX).

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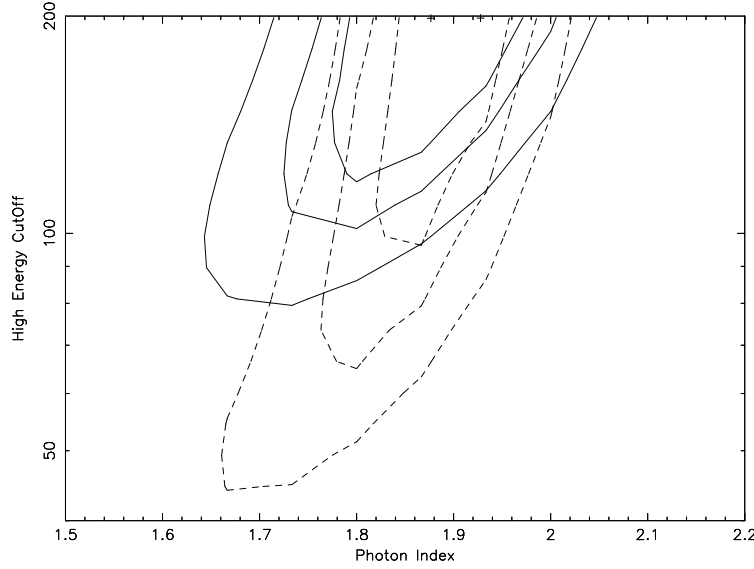


FIGURE 2. Comparison of the confidence contour levels for the high energy cutoff (in units of keV): solid contours have been derived analysing EPIC-IBIS joint spectrum, while the dashed contours mark the BeppoSAX results.

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